open bore at the pin nose/box ID. FIG. 5d shows a matched metal-to-metal seal contact without an OD shoulder at the box face/pin OD. FIG 5e shows a matched metal-to-metal seal on a two step thread form at the interface between the two steps. It will be understood by those skilled in the art that a matched or mismatched metal-to-metal seal may be located at any of the shown locations. It will be further understood that whether an ID shoulder or OD shoulder is included is a matter of design choice.

[0037] FIGS. 6a-f show metal-to-metal seals implemented in conjunction with torque shoulders in accordance with embodiments of the invention. FIG. 6a shows a matched metal-to-metal seal with an adjacent square torque shoulder at the pin nose/box ID. FIG. 6b shows a matched metal-to-metal seal at the pin nose/box ID with an adjacent reverse angle torque shoulder. FIG. 6c shows a matched metal-to-metal seal at the box face/pin OD with an adjacent reverse angle torque shoulder. FIG. 6d shows a two-step thread form having a matched metal-to-metal seal on the smaller step with an adjacent reverse angle torque shoulder at the interface between the two steps. FIG. 6e a two-step thread form having a matched metal-to-metal seal on the larger step with an adjacent reverse angle torque shoulder at the interface between the two steps. FIG. 6f shows a two-step thread form having a series of matched metal-to-metal seals in an S-shaped configuration with adjacent square and reverse angle torque shoulders located at the interface between the two steps. It will be understood by those skilled in the art that the configurations described above are exemplary and the features shown therein can be combined in different variations without departing from the scope of the invention. Further, it will be understood by those skilled in the art that whether the metal-to-metal seal is matched or mismatched and whether the torque shoulder is square, reverse angled, or otherwise is a matter of design choice.

[0038] The torque shoulders disclosed can incorporate various types of sealing mechanisms. A typical metal-to-metal seal, hook shoulder, square shoulder with

frustrum (conical or line-contact), and annular shoulder seals. Locked double-shoulder metal-to-metal seals incorporated into the torque shoulder. Elastomeric seals, especially including an elastomeric seal in the groove of a double-shoulder seal configuration. Geometries of the elastomeric seal and groove are designed to insure extrusion of the seal material at make-up. Double-shoulder thermoset resin seal (described below) Certain types of seals, notably the locked double-shoulder metal-to-metal seal located at the torque shoulder, require a high degree of centering action to engage properly and make an effective seal. The progressive engagement feature of the wedge thread (root/crest, then both flanks, in a prescribed order) is an effective means of centering the connection for these types of sealing mechanisms.

[0039] In one or more embodiments, for certain applications, a helical relief groove is located at the root/crest interface to insure that pipe-dope entrapment does not plastically deform the connection during power-tight make-up. When made-up power-tight, the locked double-shoulder metal-to-metal seal may, due to the sequence of sealing of metal-to-metal seals, trap pipe dope within the confines of the seal and develop extremely high hydraulic pressures. Experience with a similar configuration in a two-step wedge thread has revealed that some means to relieve the hydraulic pressure is required to prevent deleterious plastic deformation of the connection in such a situation.

[0040] A helical relief groove may be placed in the root/crest and extend into the double-shoulder seal to provide an escape path for trapped pipe-dope. Additionally, the sealing sequence at power-tight make-up may be altered so that the seals engage starting from the axial centerline of the connection and working outwards. Sealing in this fashion insures that trapped pipe-dope will migrate radially outward towards the helical pressure relief groove.

[0041] A double-shoulder thermoset resin seal can be accomplished with loose-fitting double-shoulder grooves, one of which is filled with low temperature thermoset resin (such as epoxy or phenoloc resins), capped and retained in the groove by a "doughnut" of thin thermoplastic tubing filled with fast-reacting catalyst. When the connection is made-up power-tight, the elements of the double-shoulder seal mesh together axially, rupturing the catalyst "doughnut" and causing the resin to set.

[0042] The invention has many distinct advantages over the prior art. A wedge thread design is disclosed that incorporates the basic functions of a prior art wedge thread configured with a positive stop torque shoulder. Typically, this invention is used in conjunction with a conical metal-to-metal seal, but is not limited to it. In one embodiment, in one aspect, the invention offers a positive stop torque shoulder that can work in conjunction with the wedge thread torque stop as a primary torque shoulder. In one embodiment, in one aspect, the invention offers a positive stop torque shoulder that can work in conjunction with the wedge thread torque stop as a secondary torque shoulder. In one embodiment, in one aspect, the invention offers a positive stop torque shoulder that can work independent of the wedge thread as a torque shoulder when the connection is made up.

[0043] As used herein, and as conventionally understood where tubular joints are being connected in a vertical position such as when making up a pipe string for lowering into a well bore, the term "load flank" designates the side wall surface of a thread that faces away from the outer end of the respective pin or box member on which the thread is formed and supports the weight of the lower tubular member hanging in the well bore. The term "stab flank" designates that side wall surface of the thread that faces toward the outer end of the respective pin or box member and supports the weight of the upper tubular member during the initial make-up of the joint.